CONDITIONING, PRE-TREATMENT AND STORAGE

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Results from project activities by DTI and Ocean Rainforest

24-03-2021 MacroCascade Final Conference

Challenges

- Seaweed biomass is harvested at specific times of the year

  -> year-round processing requires storage from harvest to further biorefining

- Seaweed biomass has high water content

  -> dewatering may reduce the quantity of biomass to be handled

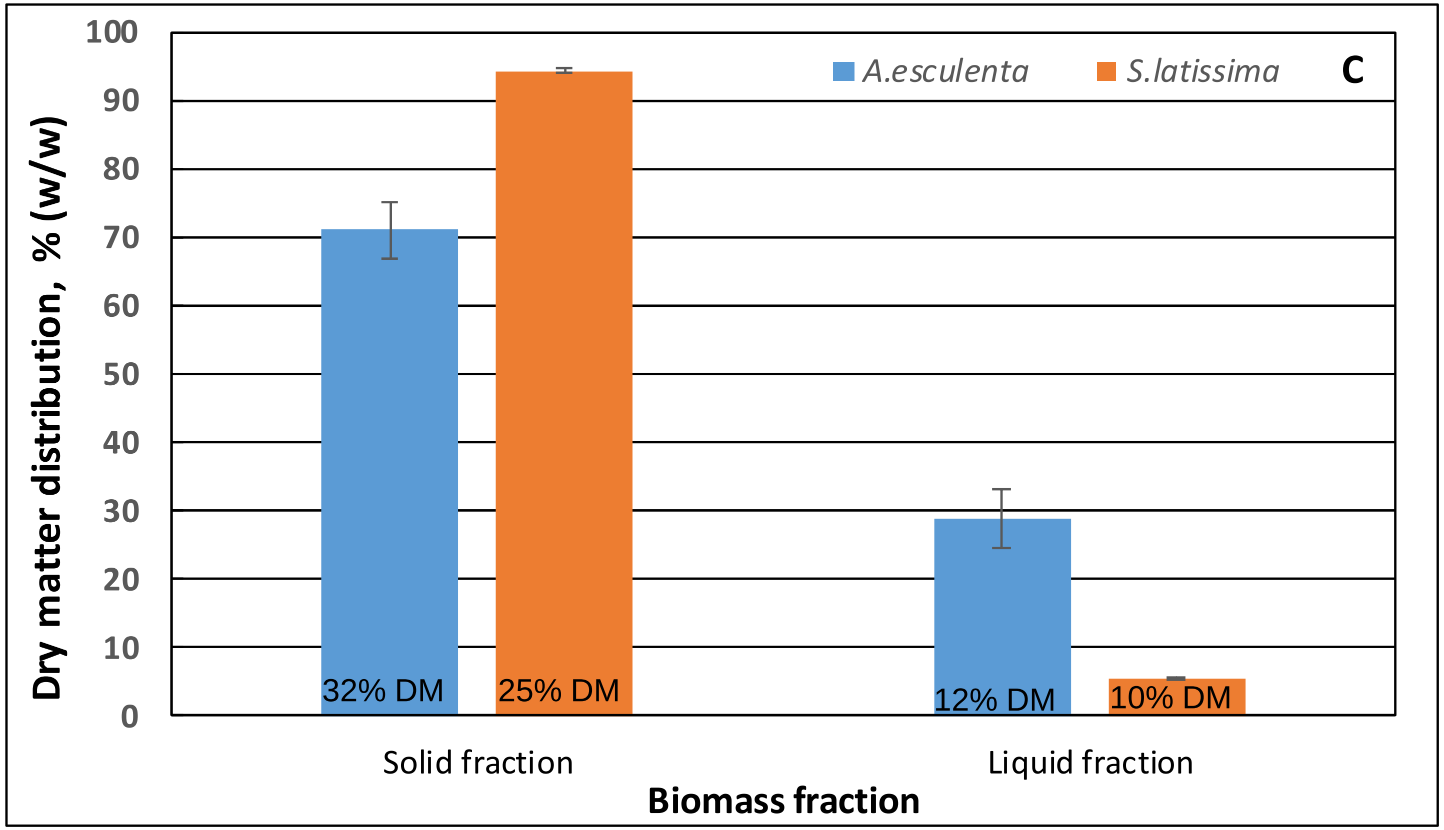
  -> drying may preserve constituents – but requires energy

  -> ensiling may be energetically advantageous to drying

- Pre-treatment and storage should preserve valuable constituents

Dewatering / chopping

- Screw-pressing of fresh seaweed can produce a solid fraction with a high share of the DM
- A possible step before drying
- There is still some DM in the liquid fraction – must be handled
- Screw-pressing / chopping may aid consolidation of the biomass and potentially the ensiling process

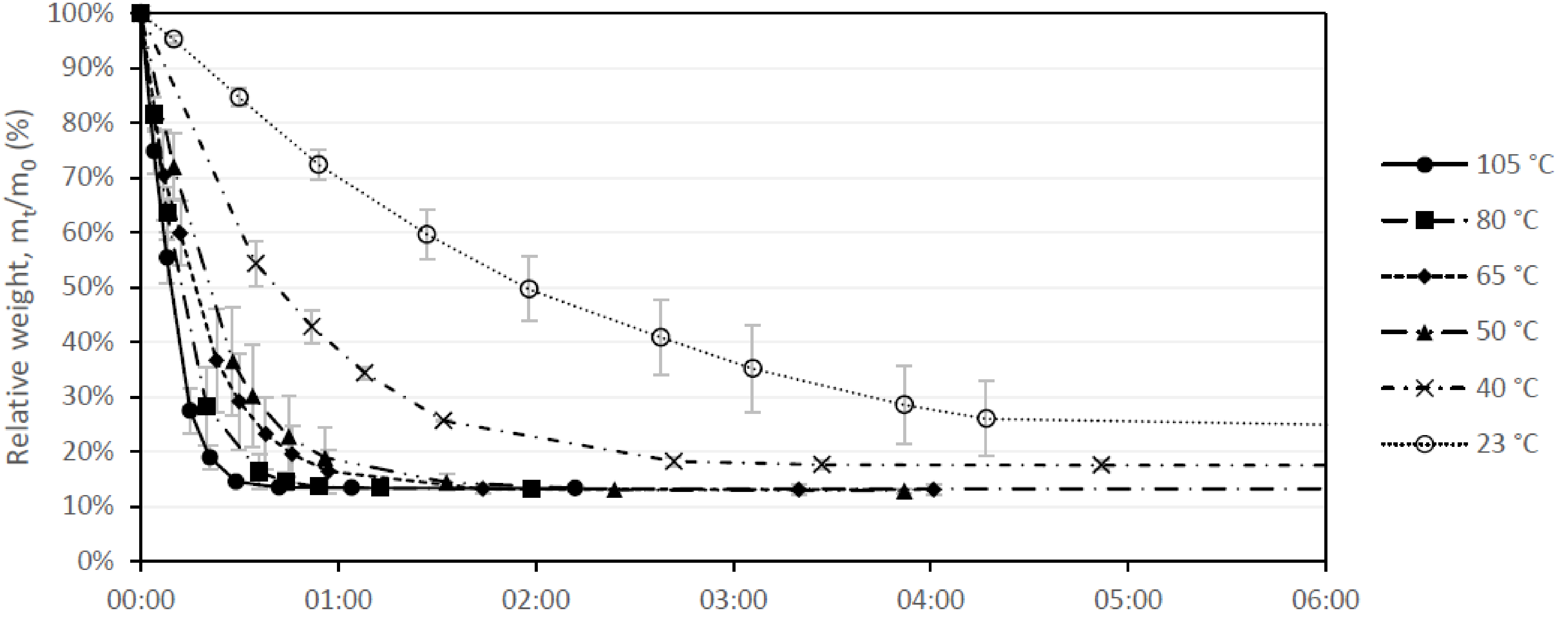


Drying

- Drying can be done by various technologies, e.g. rotary dryers, conveyor dryers, flash dryers and fluid bed dryers
- Drying costs must be weighed against preservation of valuable constituents

Drying

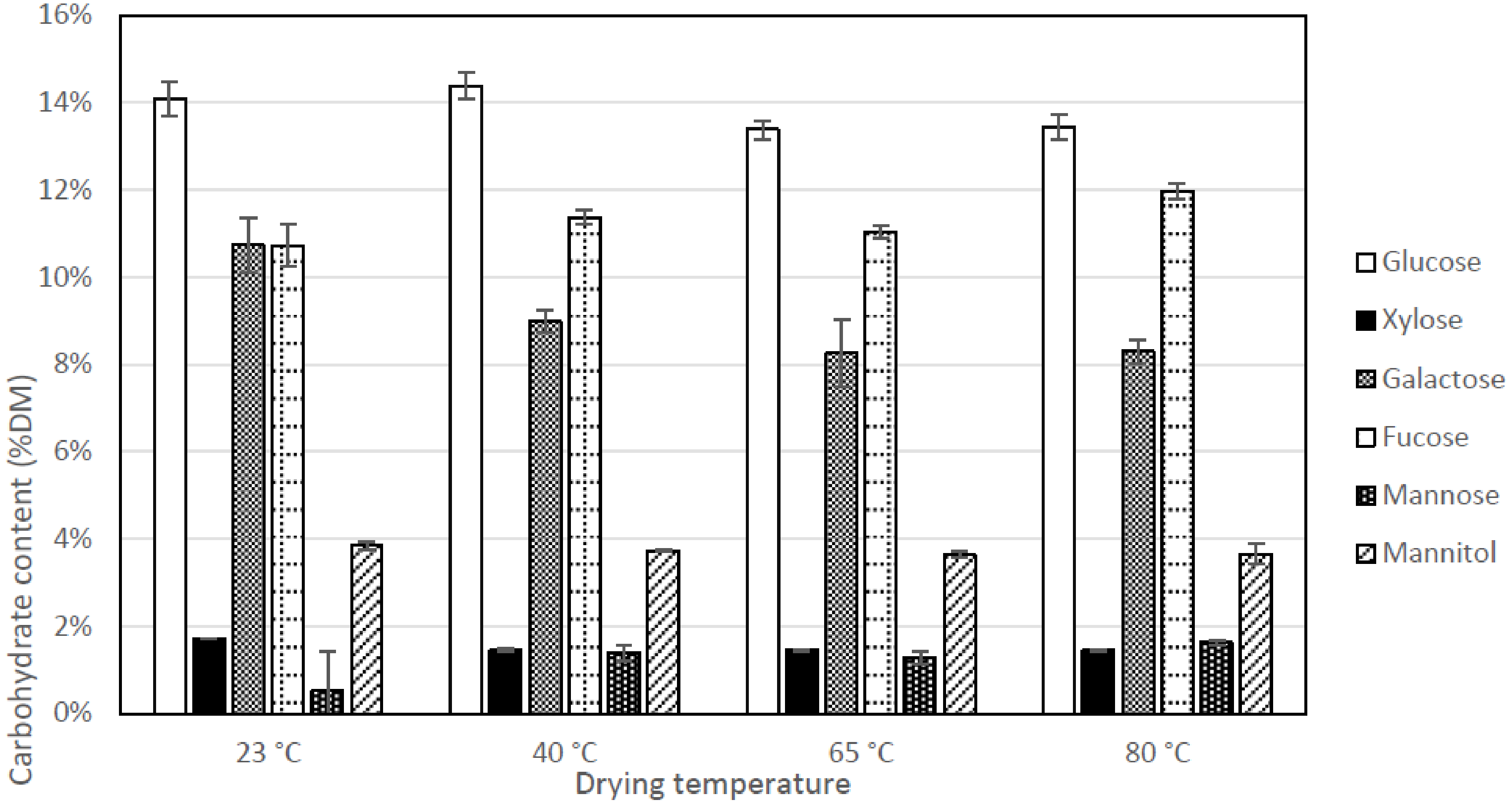
- Lower temperature causes slower drying, and some moisture may still retain in the biomass
- Dried seaweed must be stored airtight to avoid subsequent water absorption



Drying by convective heating of S. latissima at different temperatures

Drying

- Carbohydrates and proteins may both be affected by increasing drying temperature – but drying at 40°C generally ensures good preservation



Sugar content of seaweed after drying at various temperatures.

Ensiling

Ensiling preserves wet biomass by reducing pH to around 4.0

- ‘Biological ensiling’: Production of organic acids by bacteria
- ‘Chemical ensiling’: Addition of mineral or organic acids

Various ensiling experiments with *Saccharina latissima*: Effects of ensiling additives and duration on pH, carbohydrate composition and protein content

- Lab-scale ensiling in vacuum bags – up to 12 months
- Pilot-scale ensiling in barrels – 12 months

Procedure for lab-scale ensiling

Frozen *Saccharina latissima*

The solid fraction chopped, liquid fraction added in original proportion

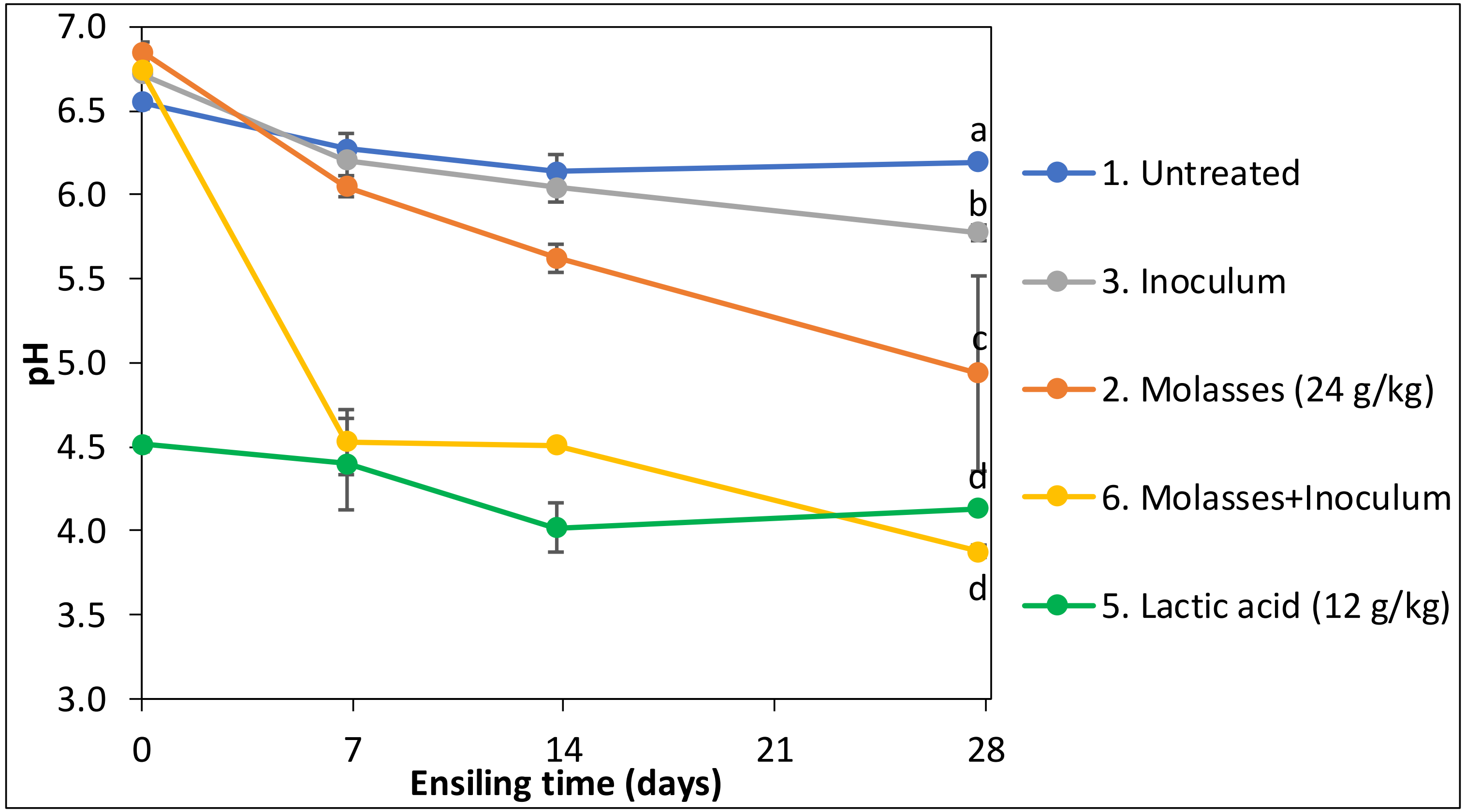
Additives added into bags with 50 g of biomass

Vacuum packing and storage at 20ºC
Freezing after pre-planned ensiling time

Duplicates or triplicates
Destructive sampling for later analysis of pH, carbohydrates etc.

Ensiling of *S. latissima*

- Often poor ensiling without additives – but ensilability differs between batches!
- Lack of inoculum and especially WSC appears to limit ensiling

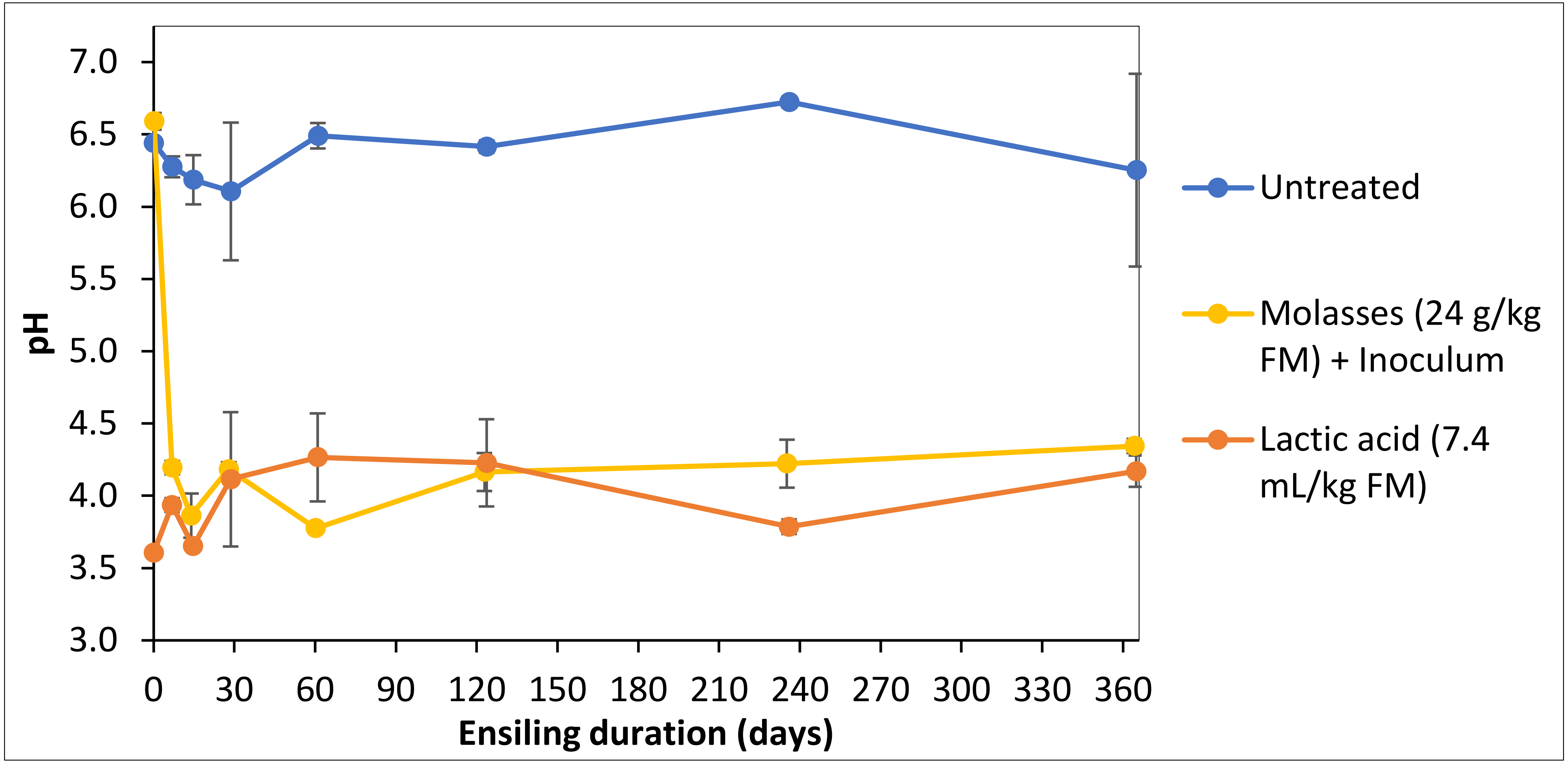


S. latissima from Ocean Rain Forest, Faroe Islands 13th July 2016

Letters indicate LSD groups (P<0.05)

Long-term ensiling – pH

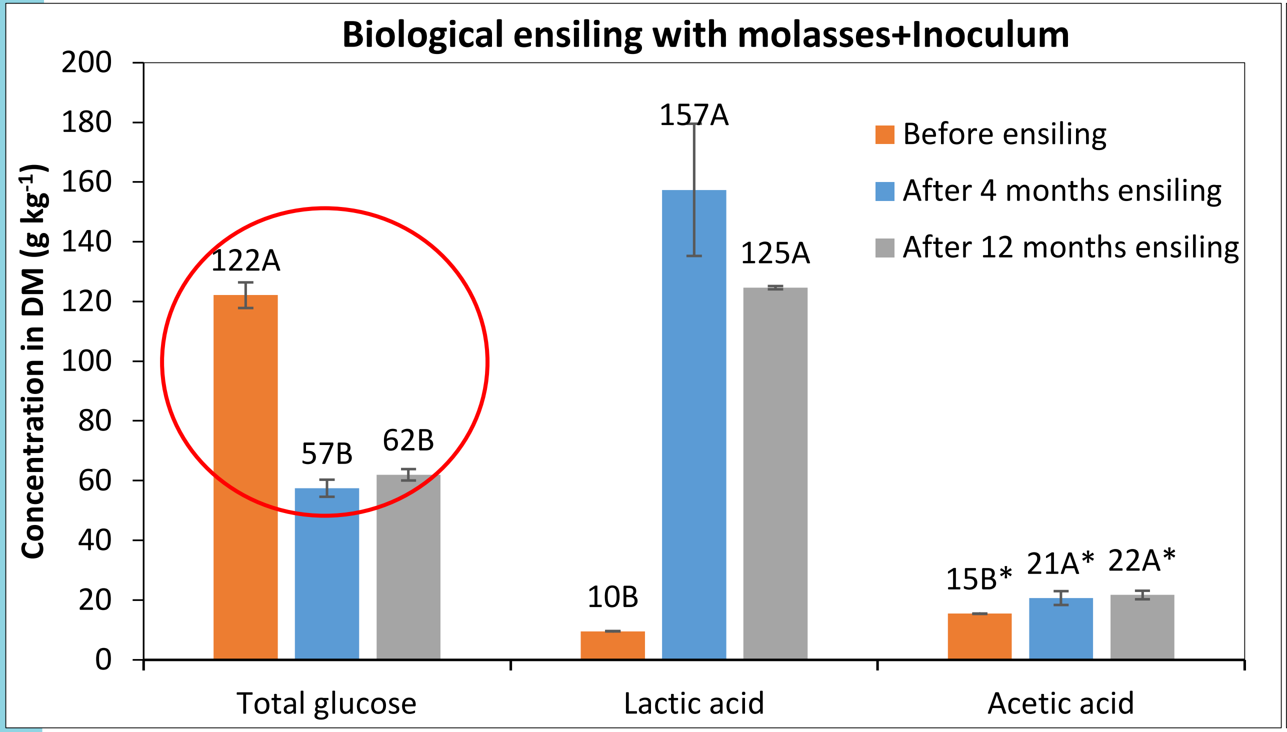
- Both biological and chemical ensiling can retain low pH (≤4.3) up to one year

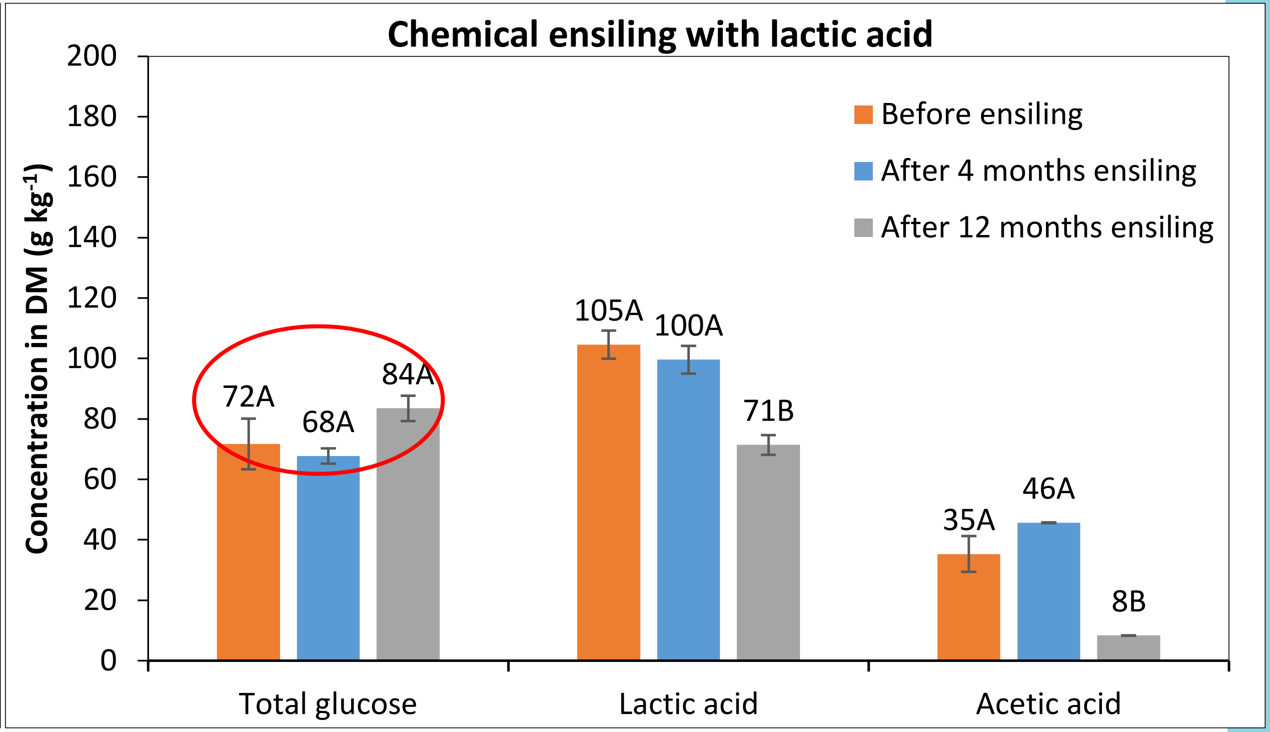


S. latissima from Ocean Rain Forest, Faroe Islands 13th July 2016

Long-term ensiling – glucose

- Initial conversion of glucose to lactic acid during biological ensiling
- Glucose content stabilized by chemical ensiling
- Some degradation of lactic acid over time

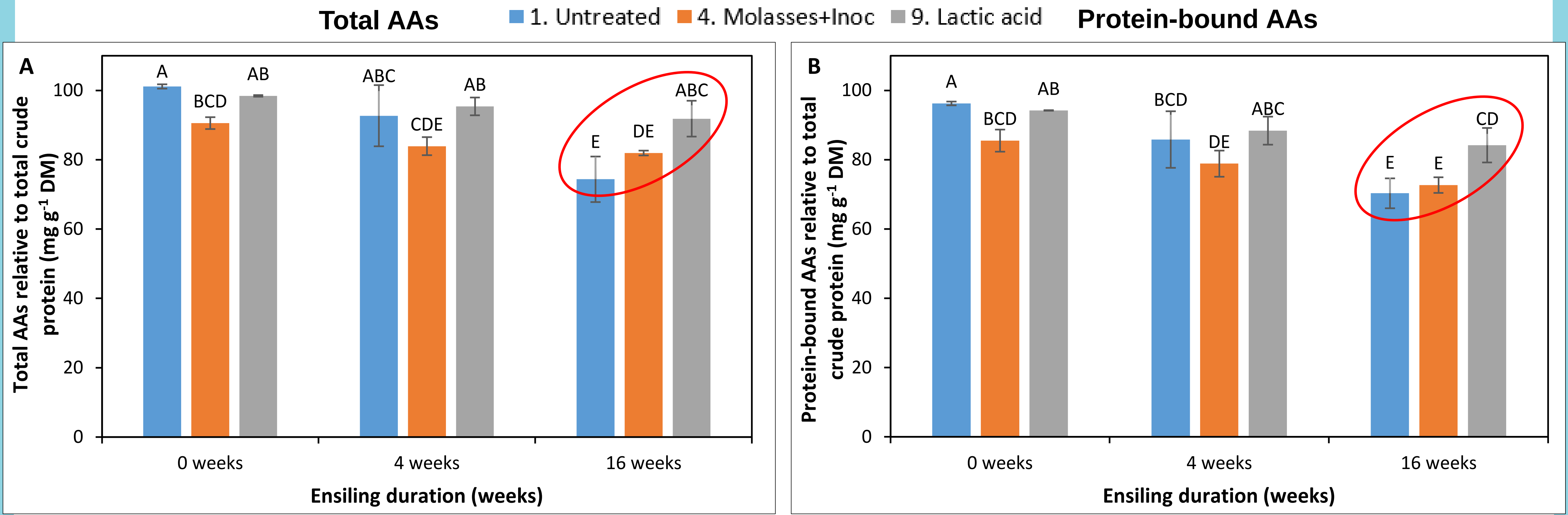




S. latissima from Ocean Rain Forest, Faroe Islands 13th July 2016

Long-term ensiling – protein

- Total amino acids (AAs): Only significant reduction without ensiling additives
- Protein-bound AAs: Reduced for all treatments – but less with chemical ensiling



S. latissima from Ocean Rain Forest, Faroe Islands 13th July 2016

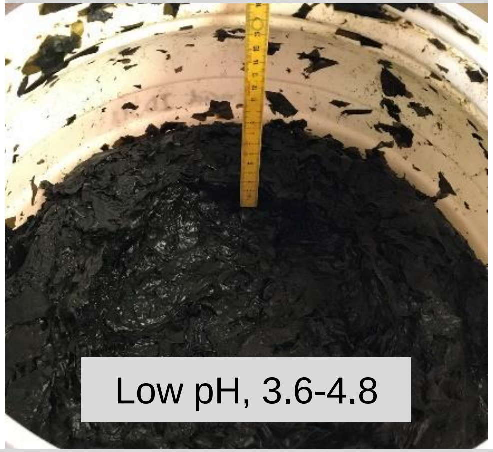
Pilot-scale ensiling for 12 months

Harvest of cultivated *S. latissima*

Chopped biomass mixed with additives
Either glucose+inoculum or lactic acid

Ensiling in 68 L barrels for 12 months

No mould on the surface – oxygen effectively excluded! (quality barrels)



Low pH, 3.6-4.8

Draining of liquid fraction from solid fraction, analyses for mass balance

S. latissima from Ocean Rain Forest, Faroe Islands 14th May 2018

Pilot-scale ensiling for 12 months

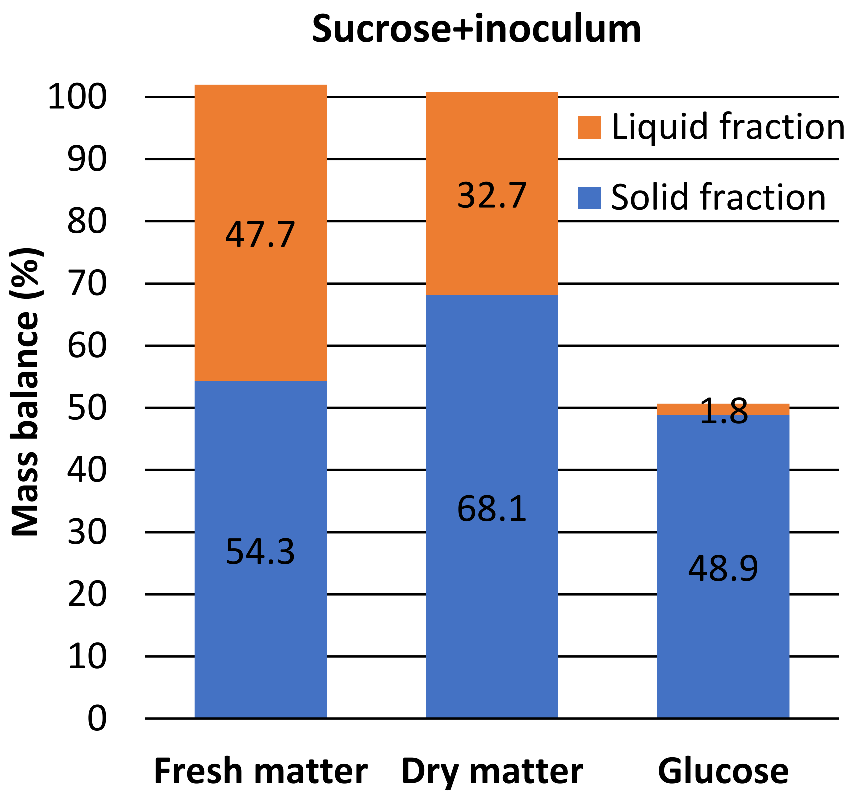
- Carbohydrate analyses of solid and liquid fractions after 12 months ensiling
- A general reduction in carbohydrate concentration after ensiling
- Generally larger reduction in the liquid fraction

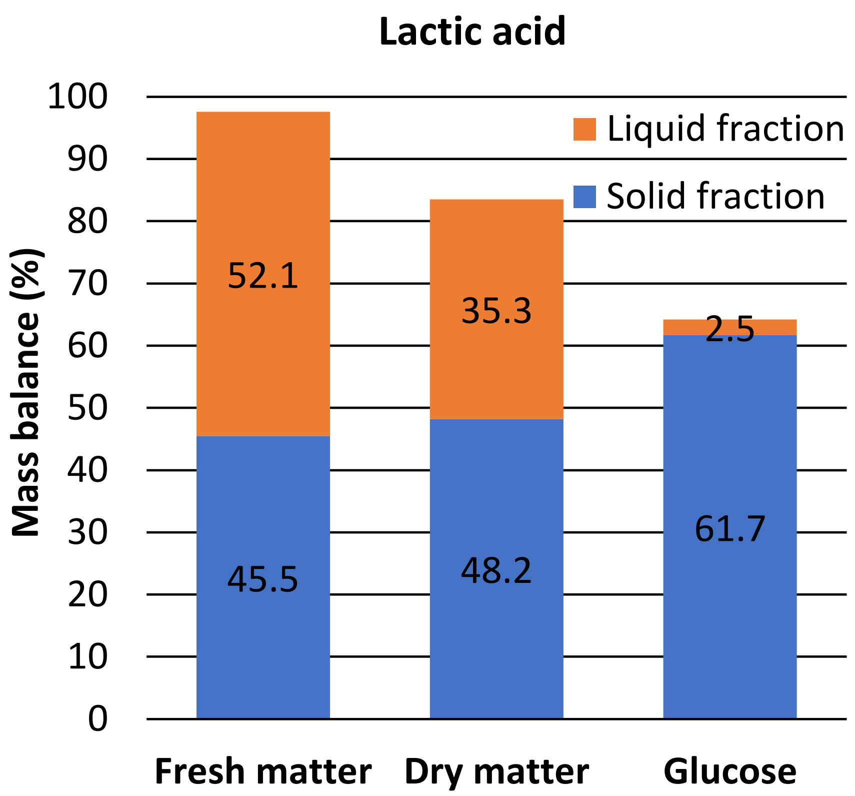
Barrel no. and additive treatment	Fraction	Glucose	Galactose	Fucose	Mannitol
		(% in DM)			
Fresh unensiled	Total	9.8% ± 3.4%	2.4% ± 0.6%	3.4% ± 1.6%	9.5% ± 0.2%
Barrel 1: Sucrose (10.3 g/kg FM) + SiloSolve	Solid	10.1% ± 0.1%	2.1% ± 0.2%	1.1% ± 0.1%	5.1% ± 0.6%
	Liquid	0.8% ± 0.3%	1.0% ± 0.0%	1.4% ± 0.2%	3.2% ± 0.7%
Barrel 1: Lactic acid (7 g/kg FM)	Solid	12.3% ± 0.8%	2.9% ± 0.2%	2.0% ± 0.0%	2.4% ± 0.4%
	Liquid	0.7% ± 0.5%	0.9% ± 0.0%	1.1% ± 0.1%	3.3% ± 0.5%

S. latissima from Ocean Rain Forest, Faroe Islands 14th May 2018

Pilot-scale ensiling for 12 months

- Glucose primarily in the solid silage fraction
- 51-64% glucose recovery, highest with chemical ensiling with lactic acid





S. latissima from Ocean Rain Forest, Faroe Islands 14th May 2018

Large-scale ensiling

IBC containers shipped from ORF

Approx. 60.000 kg silage in 2020!

Photos: Ocean Rainforest

Conclusions

- Dewatering by e.g. screw-pressing can give a solid fraction with most of DM – i.e. smaller quantity to be handled
- Drying at relatively low temperatures (≤40°C) can preserve carbohydrates and protein relatively well
- Ensiling is energetically interesting for preservation of wet seaweed – but carbohydrates are consumed and protein may be degraded
- Choice of preservation method for seaweed may depend on the costs and the subsequent application of the biomass

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